



# **INTEGRATED WATER RESOURCES MANAGEMENT**

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IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to **maximise the resultant economic and social welfare** in an equitable manner **without compromising the sustainability of vital ecosystems**.

(GWP, 2000)

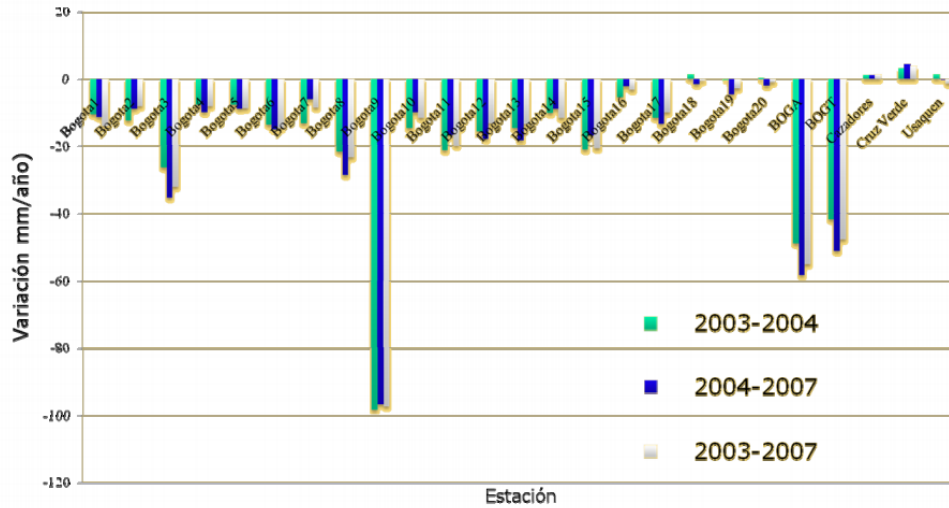
## Flooding



Flooded highway near Chia



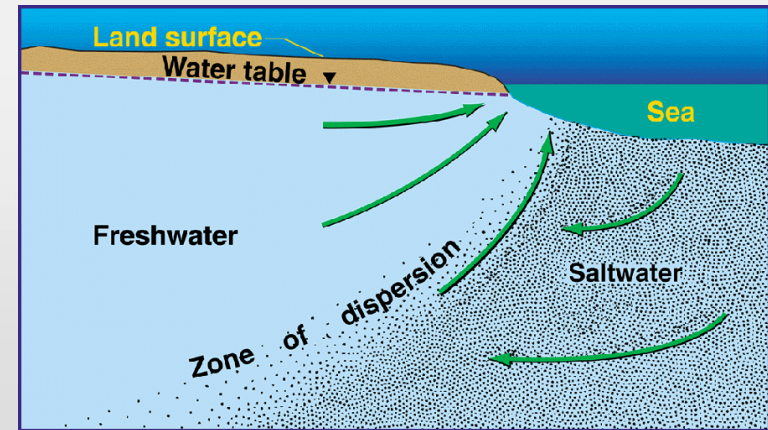
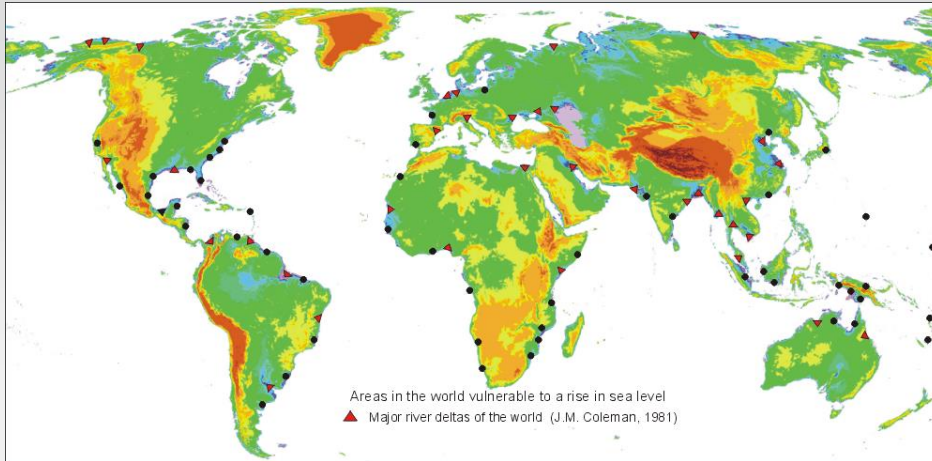
## Subsidence



Martinez et al. 2008



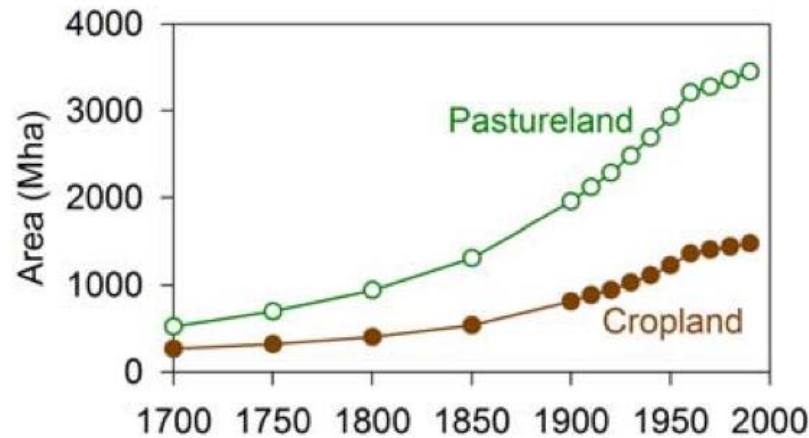
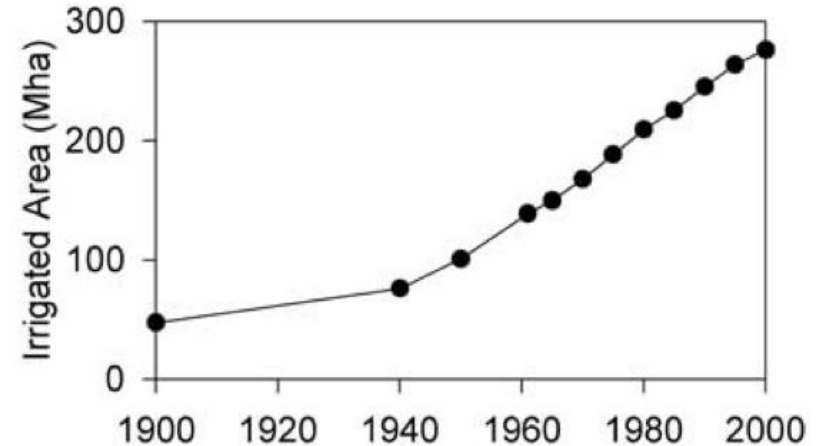
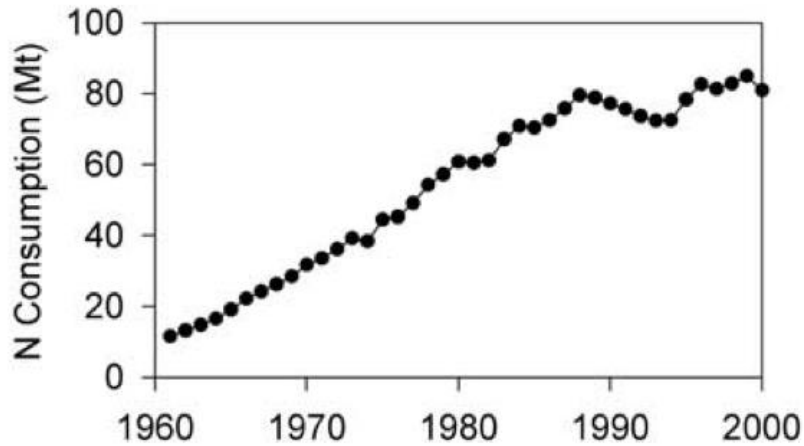
## Saline intrusion



Fuente: USGS, Groundwater division

# Why IRWM in urban basins ?

## Competing demands for water



## Poor water quality



*Acid mine drainage*  
PHOTO: SOSBlueWaters.org

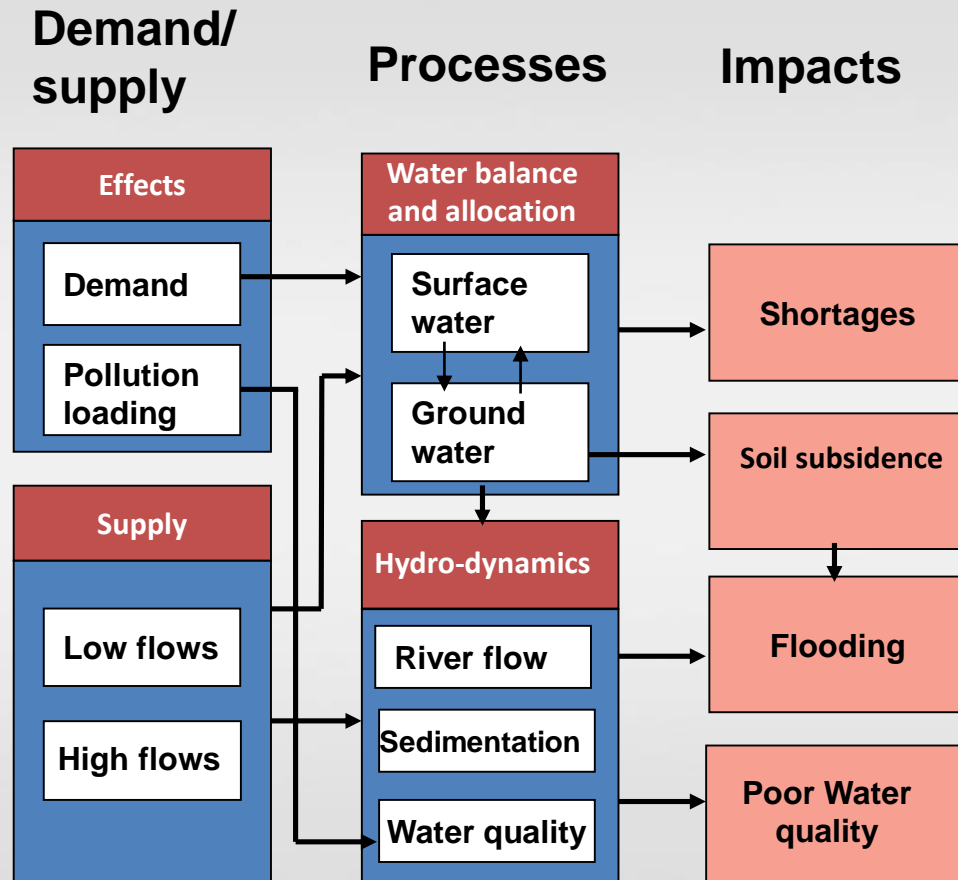


*Wet tailings disposal at a mine in Peru*  
PHOTO: Centro de Cultura Popular LABOR, Peru

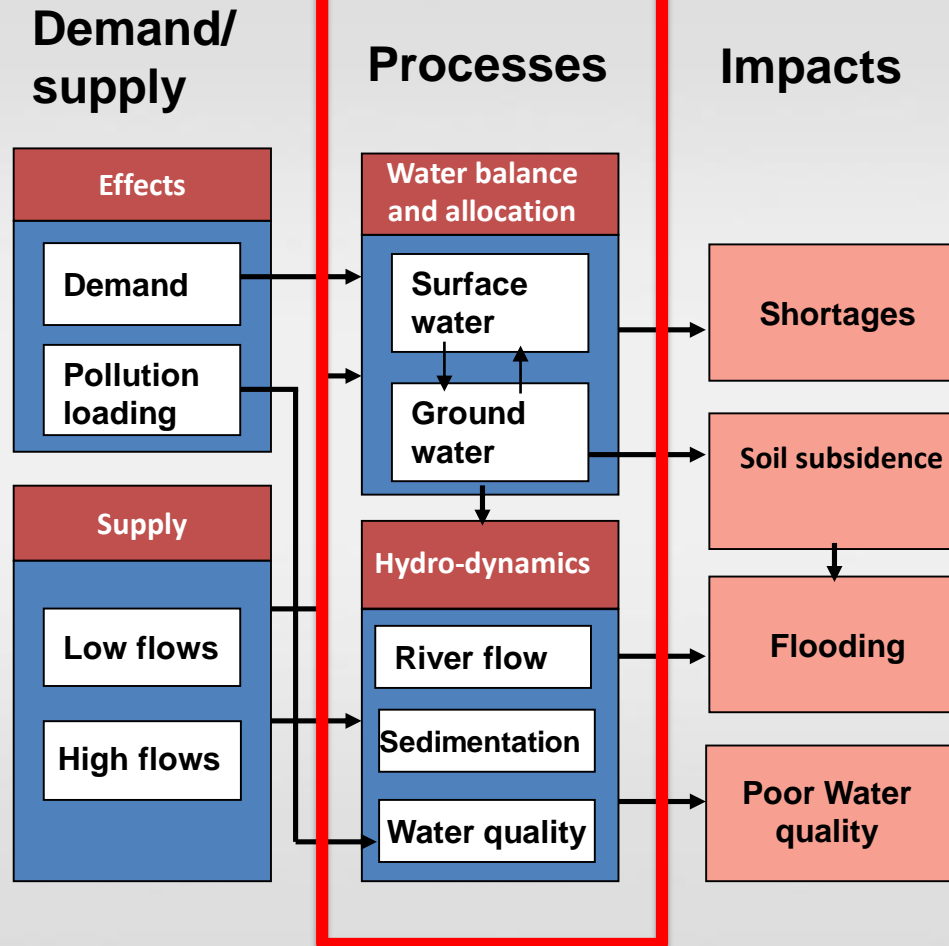
## Underlying causes in urban basins (the colombian case):

- population growth
- mining
- dams (hydroelectric power)
- mismanagement
- increased welfare and expectations
- climate variability





## NUMERICAL MODELS



- We want to manage our water resources systems
  - implement structural measures (reservoirs, river training works, irrigation areas, waste water treatment)
  - distribute the water to the various users
  - warn the stakeholders for floods and droughts
- But
  - which measures to take ? and when?
  - what will be the effect of these measures ?

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  - which measures to take ? and when?
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- Models help us to:
  - understand how the system works
  - helps us to quantify the effects
  - simulate future scenarios
  - make informed decisions

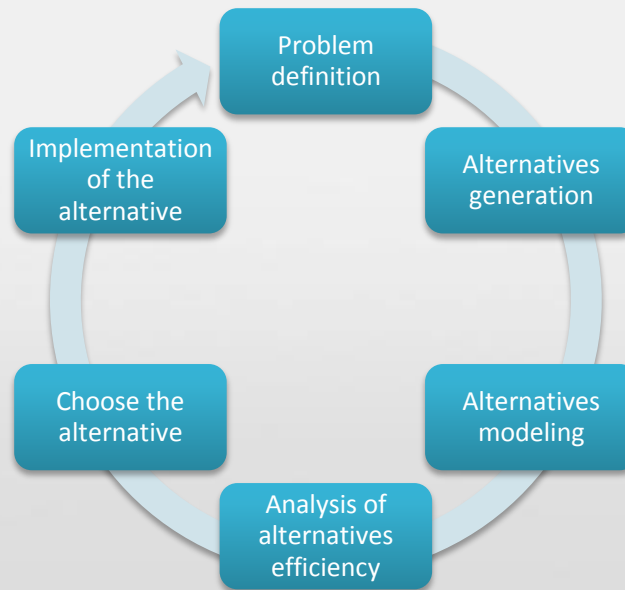
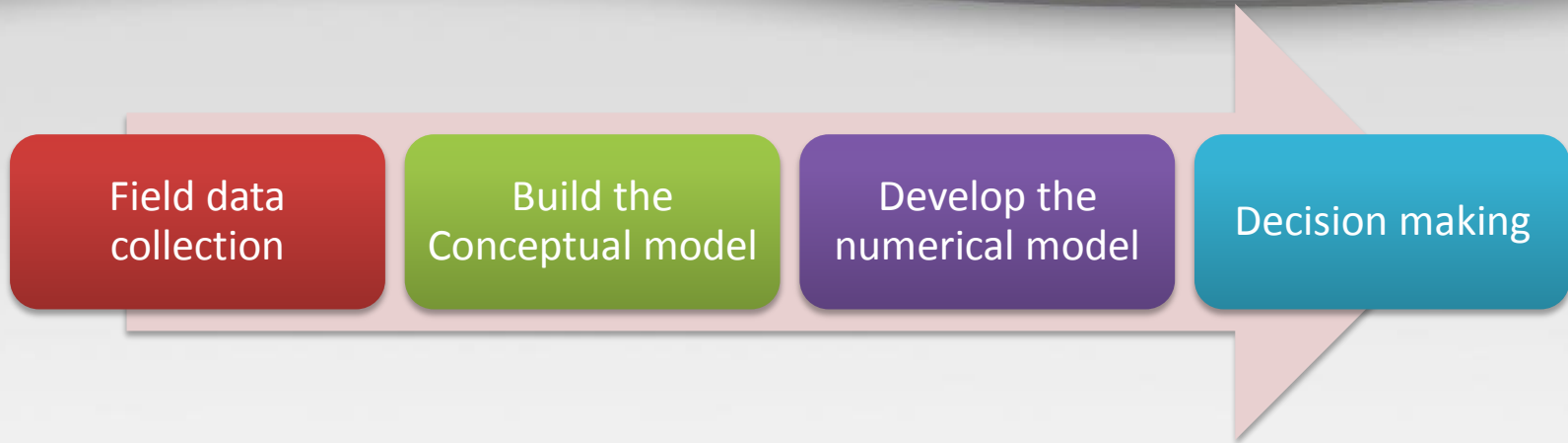


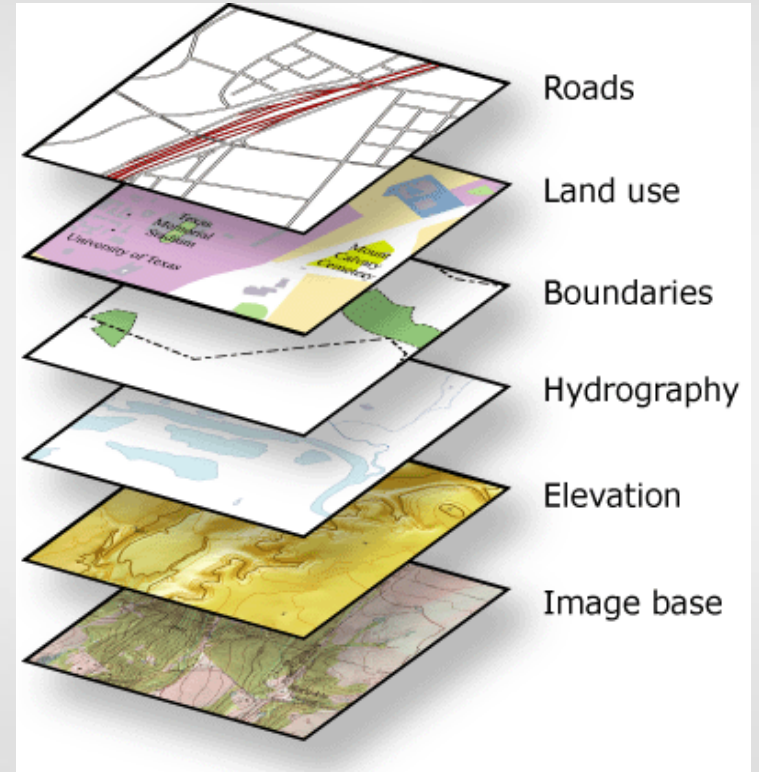
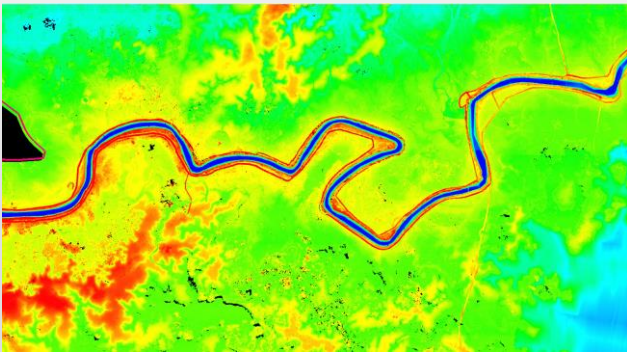
Field data  
collectipn

Build the  
Conceptual model

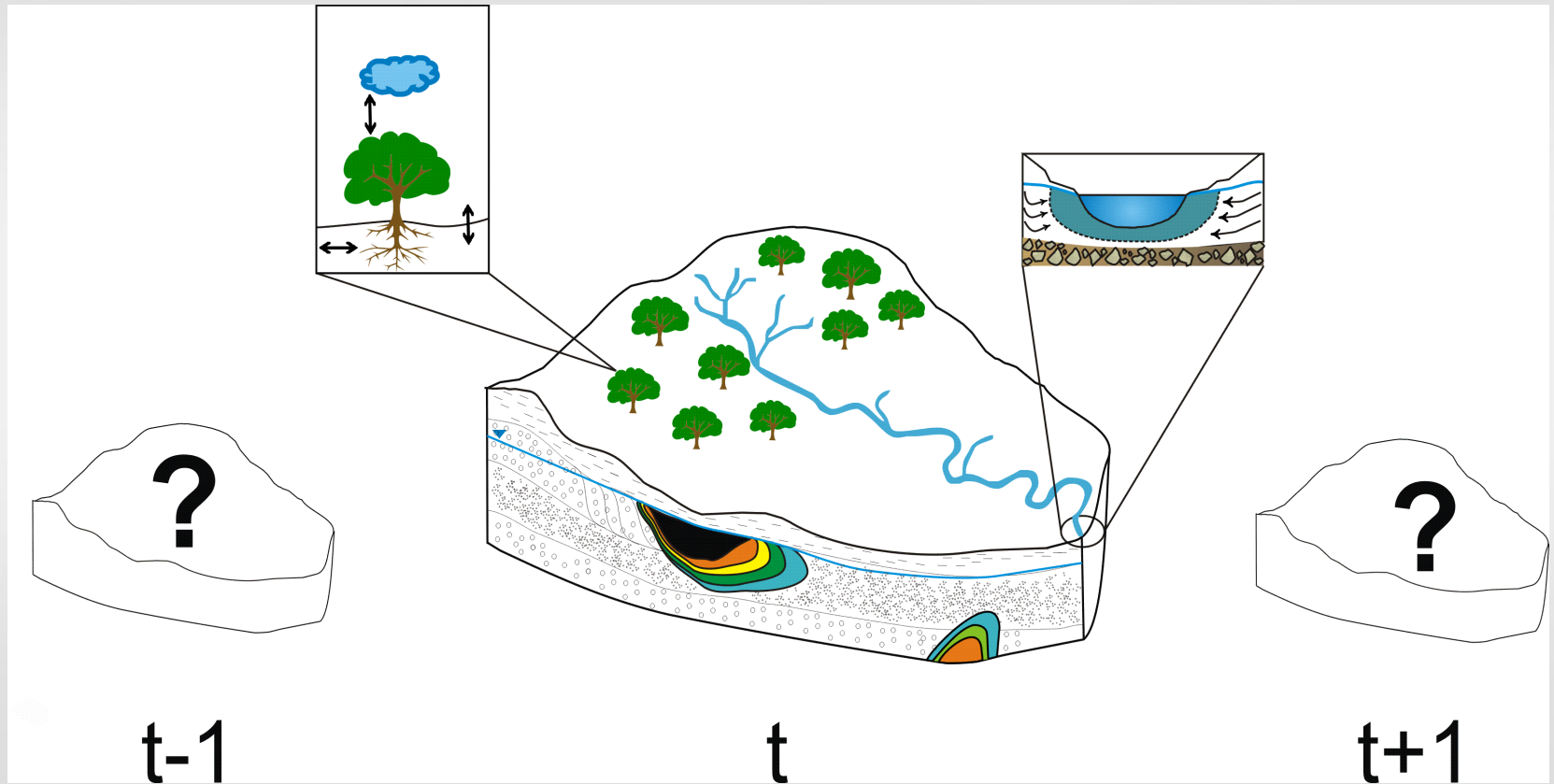
Develop the  
numerical model

Decision making



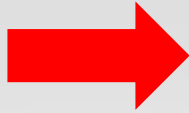


## PROCESSES AT BASIN SCALE





Input



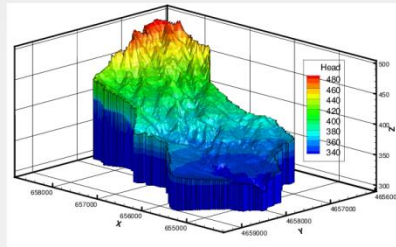
Outputs



Correlation functions  
ANN  
Genetic programming

White box

Input



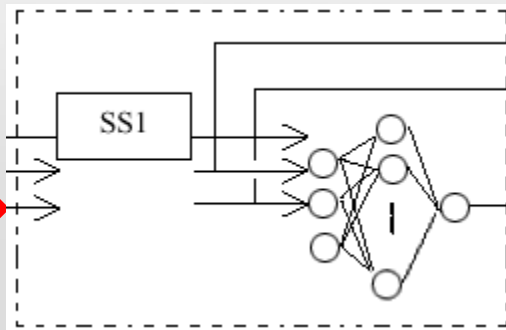
$$f(\mathbf{x}, t, \mathbf{p})$$

Outputs



Physics-based  
modeling

Input

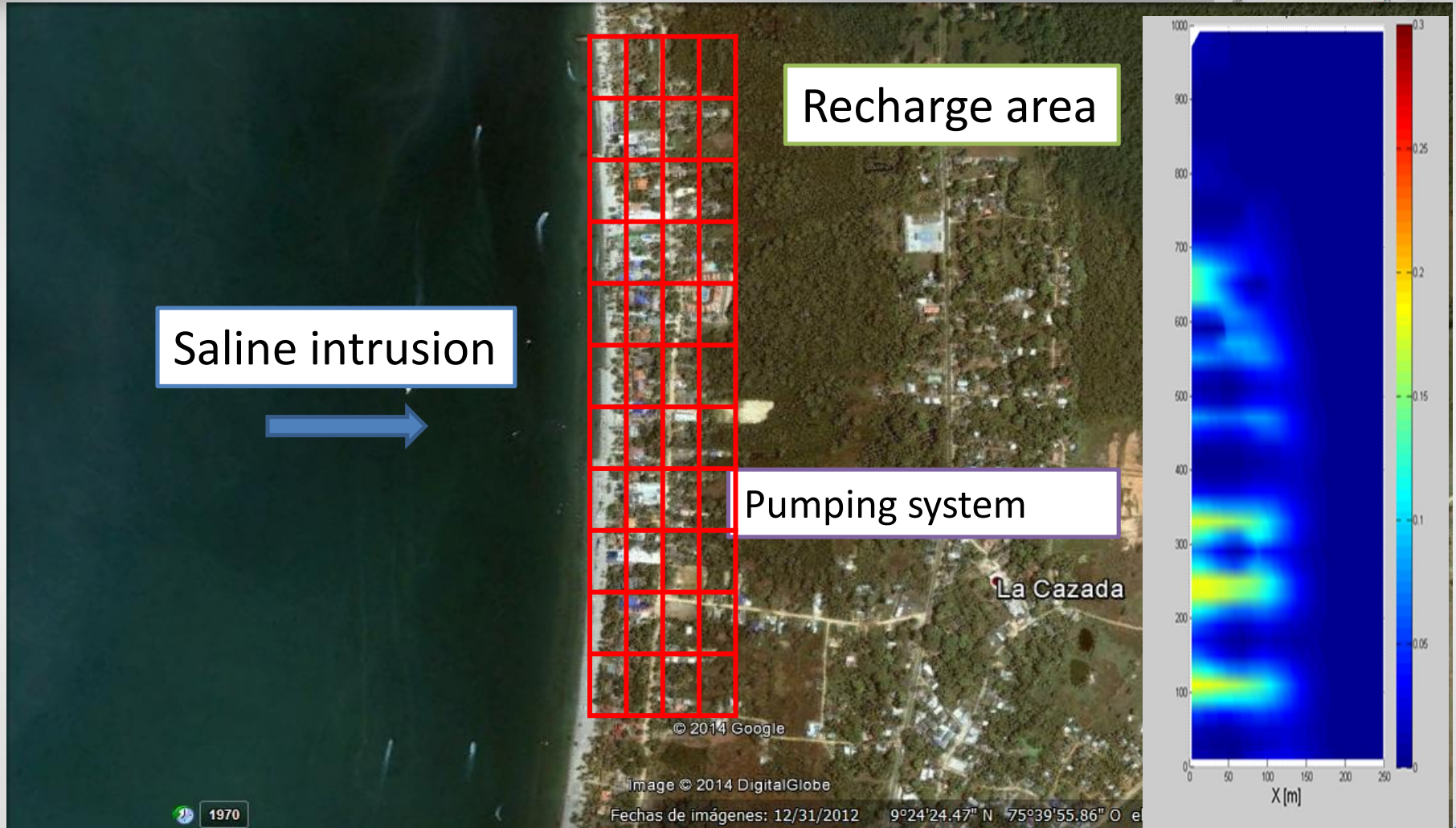


Outputs



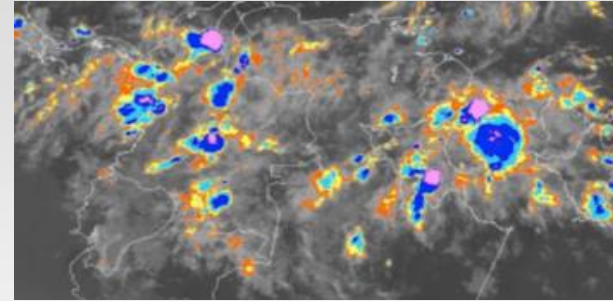
Combination of  
methods

- **Decision-makers** (actors that decide about the issue or the project, e.g:
  - Federal/state ministries/departments/agencies
- **Users** (actors that use the result or face the consequences, e.g:
  - Flood-prone communities
  - Other basin communities
- **Executors** (actors that play a role in the implementation of a decision, e.g: The private sector
- **Contributors** (actors that contribute people, resources or expertise, e.g:
  - Scientific institutions
  - Registered NGO's
  - Voluntary organizations

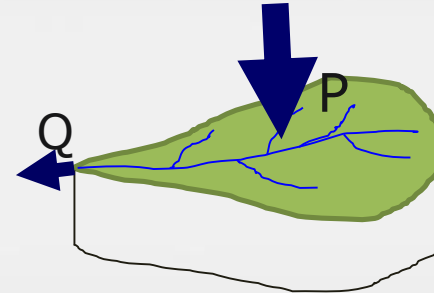


Rodríguez-Rueda & Perez, 2014.

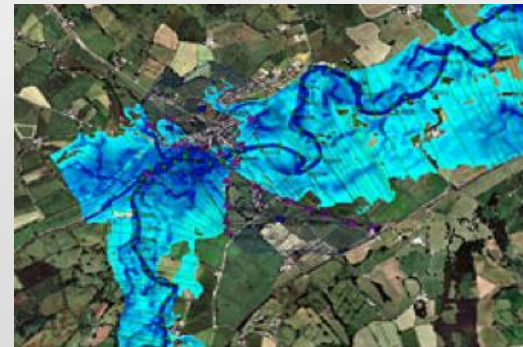
Meteorological  
models/Radar

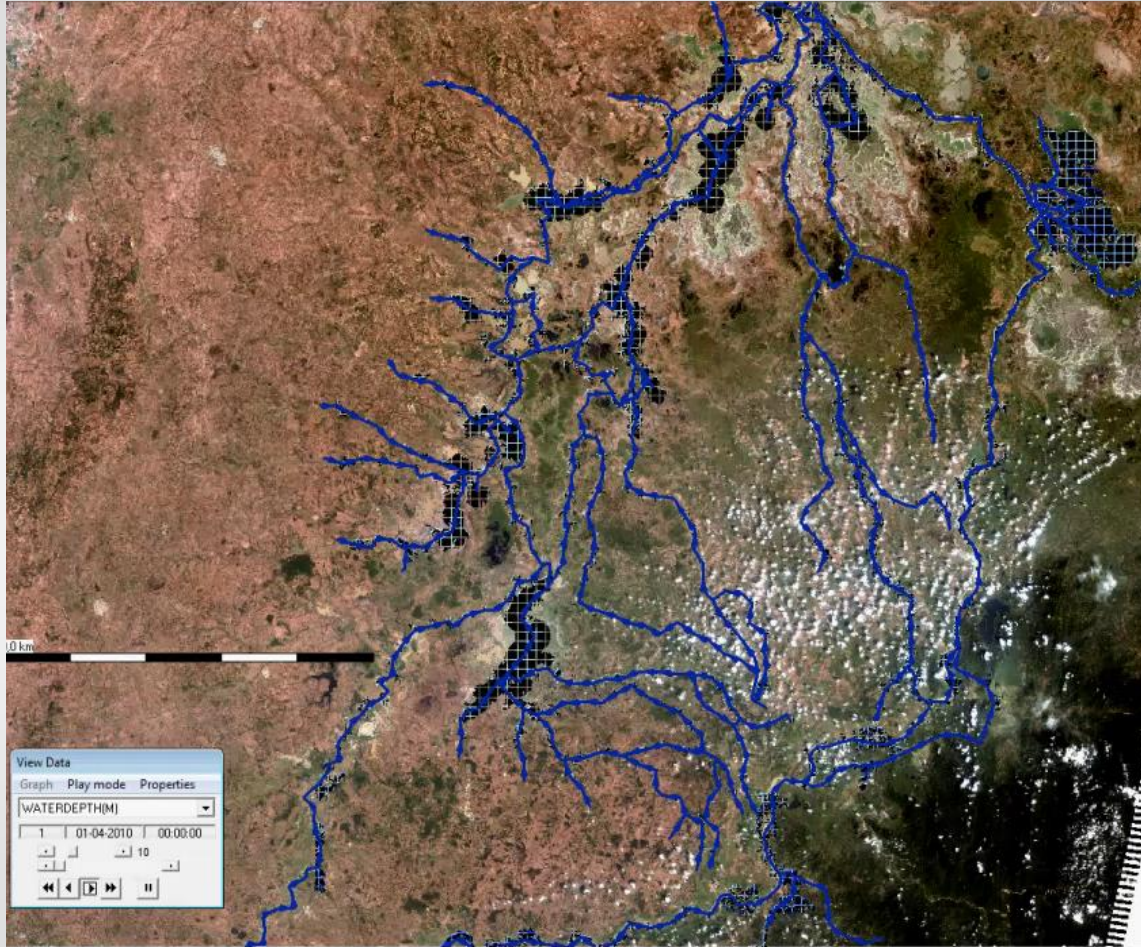


Hydrological  
models



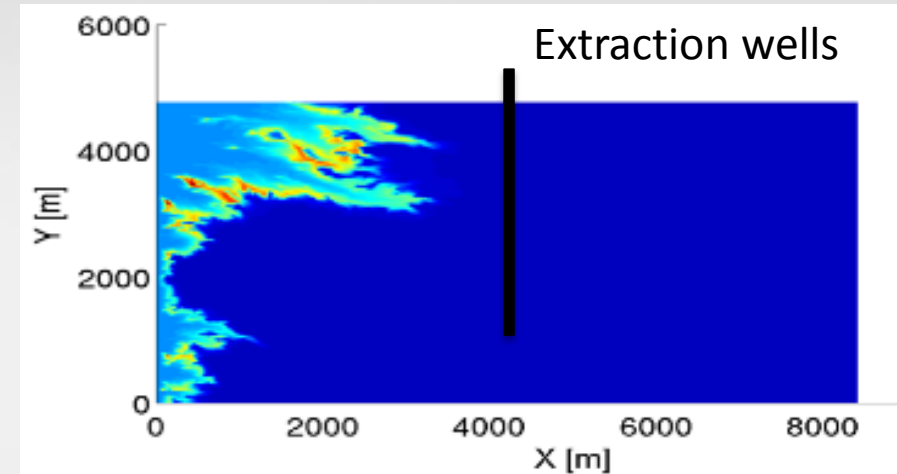
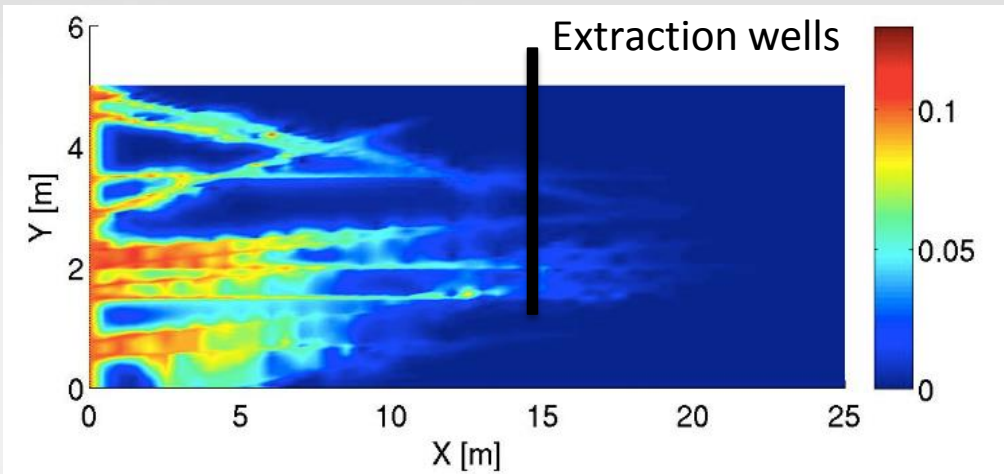
Hydrodynamic  
models



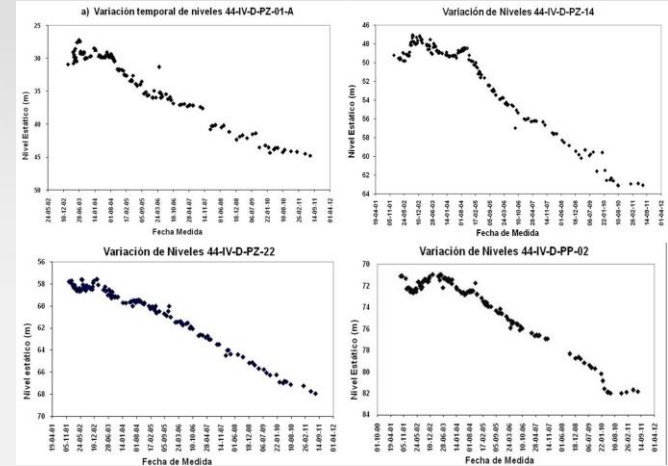


## WATERDEPTH(M)

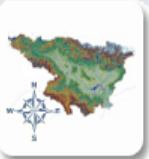






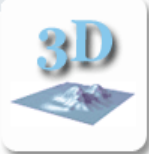


- ≤ 0.02
- > 0.02
- > 0.10
- > 0.20
- > 0.30
- > 0.40
- > 0.50
- > 0.60
- > 0.70
- > 0.80
- > 0.90
- > 1.00
- > 1.10
- > 1.20
- > 1.30
- > 1.40
- > 1.50
- > 1.60
- > 1.70
- > 1.80
- > 1.90
- > 2.00
- > 2.10
- > 2.20
- > 2.30



Fractured rock vs. heterogeneous flow



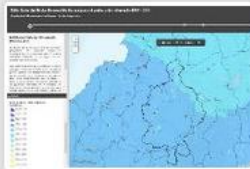
## GEOPORTAL

<p><b>Map viewer</b></p>  <p>Map View tool</p> <ul style="list-style-type: none"> <li>Files, Hydrology, Water Framework Directive</li> <li>Flood slides</li> <li>Map viewer manual</li> </ul>	<p><b>Downloads</b></p>  <p>Different formats catalog maps: JPG, SHP and JPEG.</p> <ul style="list-style-type: none"> <li>Geodata</li> <li>Images and aerial photos</li> <li>Cartography</li> <li>Download the geodata you see</li> </ul>	<p><b>Accesos directos</b></p>  <p><b>CHEbro</b> Confederación Hidrográfica del Ebro</p>  <p><b>SAIH Ebro</b> Sistema Automático de Información Hidrológica</p>  <p><b>El mejillón cebra</b></p>  <p><b>Plan Nacional de Restauración de Ríos</b></p>
<p><b>Spacial Data Infrastructure</b></p>  <p>Services based on the INSPIRE directive</p> <ul style="list-style-type: none"> <li>Ebro Spacial Data Infrastructure</li> <li>WMS Services</li> </ul>	<p><b>3D Flights</b></p>  <p>Three-Dimensional Virtual Flights</p> <ul style="list-style-type: none"> <li>Ebro Basin</li> <li>Jalon Basin</li> <li>Ebro Reservoir</li> </ul>	
<p><b>Photographs Library</b></p>  <p>Georeferenced photographs in the Ebro Basin</p> <ul style="list-style-type: none"> <li>Photographic backgrounds</li> <li>Ebro river bridges</li> </ul>	<p><b>Hydrological Plan</b></p>  <p>Hydrological Plan of the Ebro Basin</p> <ul style="list-style-type: none"> <li>Participation process</li> </ul>	

Fuente: Website Confederación Hidrológica del Ebro (CHE)



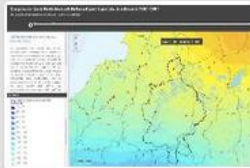
## THEMATIC MAPS GENERATION



### Brillo Solar (h) Media Mensual Multianual

Web Mapping Application by ProyectoMojana. Last Modified Jan 29, 2014.

Esta Aplicación muestra la distribución media mensual multianual del brillo solar, donde se puede apreciar un comportamiento bimodal de la variable, con dos épocas de máximo brillo solar comprendidas entre diciembre -enero y julio- agosto.



### Evaporación (mm) Media Mensual Multianual

Web Mapping Application by ProyectoMojana. Last Modified Jan 29, 2014.

Muestra la variación espacial de la evaporación media mensual multianual, se observa un gradiente latitudinal de evaporación, donde los valores mínimos se concentran al sur de la región y los máximos en sectores del centro y nororiente de La Mojana.



### Humedad Relativa (%) Media Mensual Multianual

Web Mapping Application by ProyectoMojana. Last Modified Jan 29, 2014.

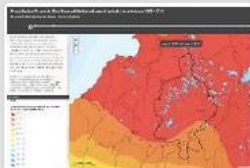
En la Aplicación se presenta la distribución media mensual multianual de la humedad relativa del aire. En términos generales se presentan altos contenido de humedad en la atmósfera en la región de la Mojana.



### Precipitación (m.m.) Media Mensual Multianual

Web Mapping Application by ProyectoMojana. Last Modified Feb 4, 2014.

Precipitación (m.m.) Media Mensual Multianual



### Precipitación Promedio (Días) Mensual Multianual

Web Mapping Application by ProyectoMojana. Last Modified Jan 29, 2014.

Mapa que muestra la distribución espacial del promedio mensual multianual de los días con precipitación, entendiéndose que se cuentan todos los valores  $\geq 0.1$  mm.



### Mapa de Fisiografía

Web Mapping Application by ProyectoMojana. Last Modified Jan 23, 2014.

Mapa realizado conforme a la metodología de Análisis Fisiográfico del Terreno (CIAF, 1997) en donde se relacionan las unidades de Provincia Fisiográfica, Unidad Climática, Unidad Genética de Relieve o Gran Paisaje, Paisaje y Sub Paisaje.



### Mapa de Geomorfología

Web Mapping Application by ProyectoMojana. Last Modified Feb 4, 2014.

Las geoformas se describen a partir de las provincias geomorfológicas y dentro de cada una de ellas se definen las unidades genéticas de relieve para concluir con los correspondientes paisajes y tipos de relieve dominantes en la región.



### Mapa de Provincia Fisiográfica

Web Mapping Application by ProyectoMojana. Last Modified Jan 24, 2014.

Mapa síntesis que presenta el primer nivel de la Clasificación Fisiográfica del Terreno (CIAF, 1997). La Provincia Fisiográfica equivale a una región morfológica en la que pueden prevalecer una o más unidades climáticas.



### Mapa de Unidades Climáticas

Web Mapping Application by ProyectoMojana. Last Modified Jan 24, 2014.

Mapa síntesis que presenta el segundo nivel de la Clasificación Fisiográfica del Terreno (CIAF, 1997). La unidad climática corresponde a la unidad de tierra dentro de la provincia fisiográfica.

## DSS FOR PLANNING

MÓDULO DE  
INFORMACIÓN

MÓDULO  
CONCEPTUAL

MÓDULO DE  
MODELACIÓN

MÓDULO DE  
ESCENARIOS



- Water supply vs. gold mining in urban basins
- Water supply vs. fracking in highly populated areas
- Water scarcity bcs of large period of drought (El Niño)
- Flooding at very vulnerable areas of big cities (La Niña)
- Touristic growth in coastal cities (water supply)
- Improve water quality at urban rivers
- Highways with large tunnels changing groundwater flowpaths



**MUCHAS GRACIAS**

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